MOBILE PHONES AS PERSONAL ENVIRONMENTAL SENSING PLATFORMS: DEVELOPMENT OF THE CALFIT SYSTEM

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Background and Aims: Mobile phones are pervasive computing technologies that offer opportunities for sensing personal behaviors and exposures to environmental hazards. The CalFit system uses the combination of global positioning system (GPS) and accelerometry on mobile phones for continuous measurements of an individual's time-activity patterns, which can greatly inform spatial and temporal variations in exposures for environmental health studies. As a research platform, CalFit was designed for flexibility, allowing its use in air pollution epidemiology, built environment, and active living research. Here, we describe the development of CalFit's algorithm for estimating energy expenditure for physical activity and minute ventilation for air pollution studies.

Methods: We describe the capabilities of the CalFit software that runs on Android mobile phones, which includes time-location tracking using GPS and the estimation of energy expenditure from triaxial accelerometry. To develop the energy expenditure algorithm, the CalFit phone was compared against the COSMED cardiopulmonary exercise monitor for 24 adult subjects (10 men and 14 women aged 19-59 years) who wore both systems simultaneously during a series of prescribed activities (four levels on treadmill spanning 1-6 mph, stair climbing, sit to stand, lie to stand, jump, and 6-minute walk test). Generalized linear equations were used to estimate COSMED measured energy expenditure and ventilation rate from the CalFit phone's vertical and horizontal accelerometry counts.

Results: In the linear model, CalFit vertical and horizontal accelerometry counts/min were significant predictors (β=0.623 P<0.001 and β=1.65 P<0.001, respectively) of COSMED energy expenditure (R^2=0.80). Inclusion of 2-minute counts improved the linear model (R^2=0.86), as did generalizing the model to account for differences between subjects (R^2=0.81). Moreover, energy expenditure and minute ventilation were linearly related (R^2=0.80).

Conclusions: Environmental epidemiology studies that require the combined assessment of energy expenditure from physical activity, minute ventilation, and time-location patterns may benefit from the CalFit phone system.